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Human Factors Considerations in the X-31 Aircraft

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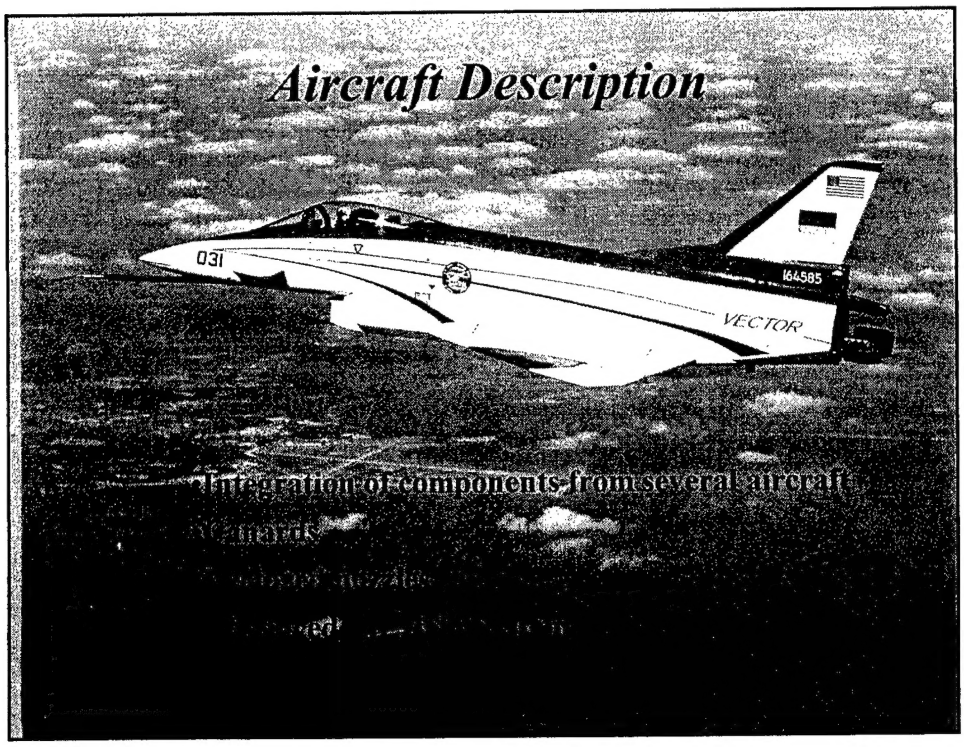
Introduction

- **Purpose**
  - Provide an insight to human factors issues that are relevant to the X-31 ESTOL maneuver
- **Background**
  - US Navy Crew System Department human factors lead engineer for the Vectoring ESTOL Control Tailless Operation Research (VECTOR) Program

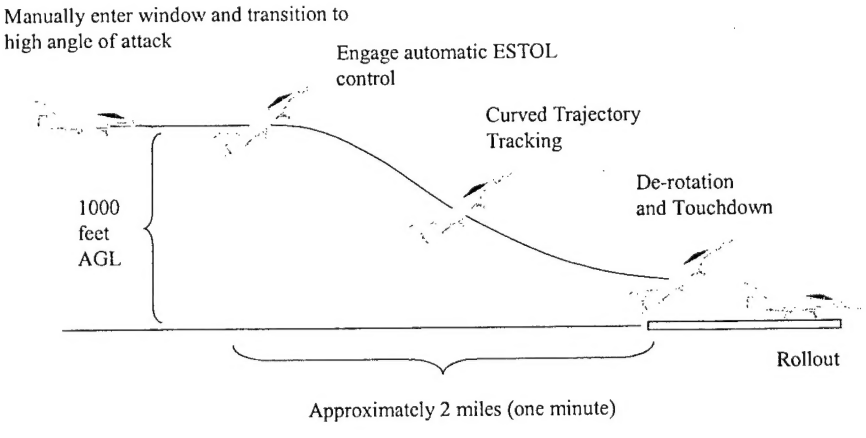


1995 Paris Air Show Video

ESTOL Maneuver

- **High alpha approach with derotation just prior to touchdown**
  - Design goal 40° alpha
    - Best payoff 25°
  - Automatic (hands off) approach and touchdown
    - Integrated Beacon Landing System (IBLS)
- **Pilot will not have direct view of runway environment**
  - Specialized display symbology
  - Indirect view of runway environment
  - Reduced workload
    - HOTAS controls
    - Location of other cockpit controls

ESTOL Approach Profile



Human Factors Issues

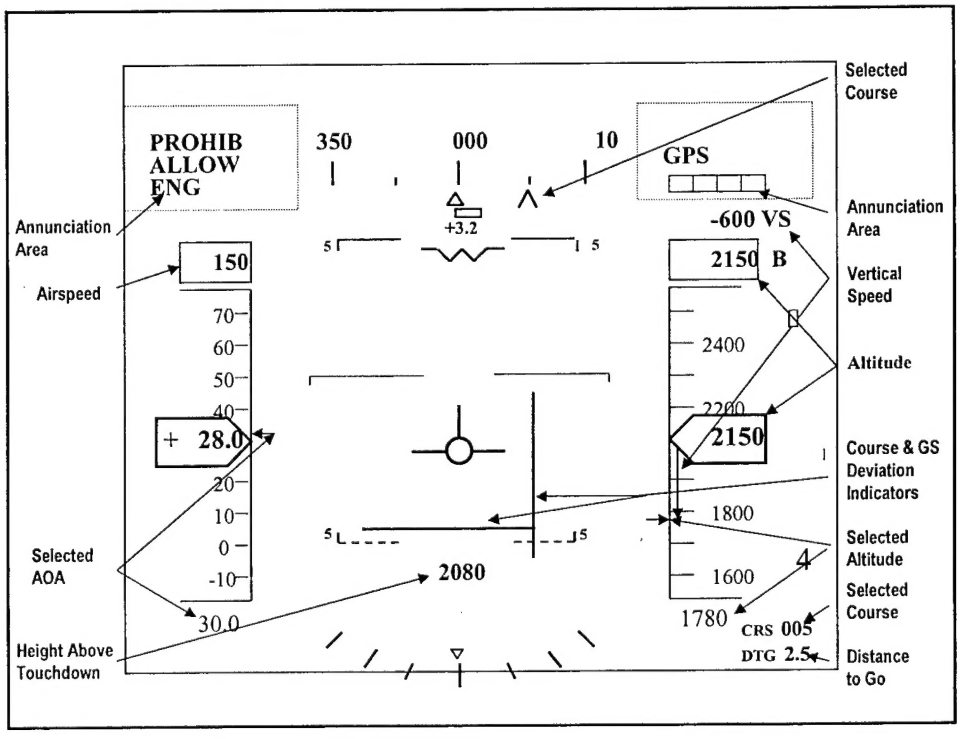
- **Display symbology**
- **Video**
- **HOTAS and other pilot controls**
- **Ejection seat**
- **O^2 regulator**
- **Communications ear plug (CEP)**

Symbology

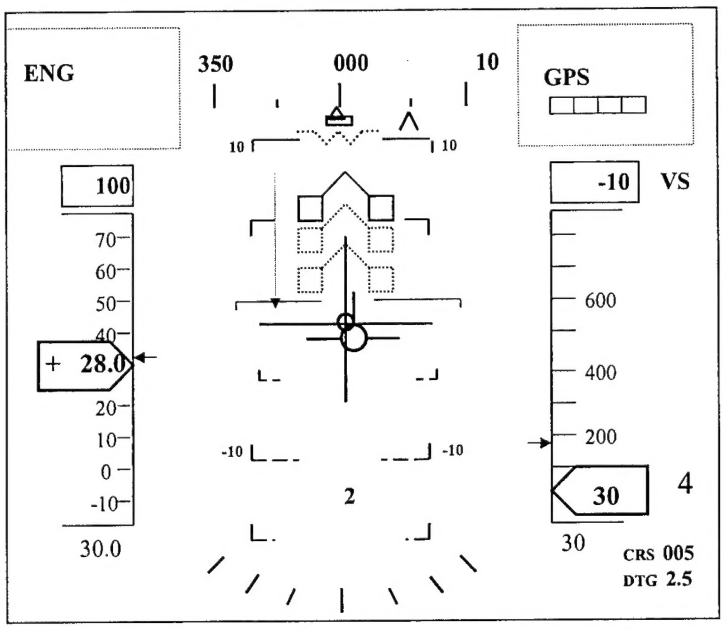
- **Modified to meet ESTOL flight profile**
  - ESTOL-specific symbology
    - Declutter during standard operations
  - Centralized scan of display
- **Primary flight display during approach**
  - HUD vs DDI
    - Opto-Kinetic Cervical Reflex
      - Difficult to assess in simulator
    - Display symbology in both displays
      - Ease of transition from DDI to HUD
      - A/C vs VV centered displays

ESTOL-Specific Symbology

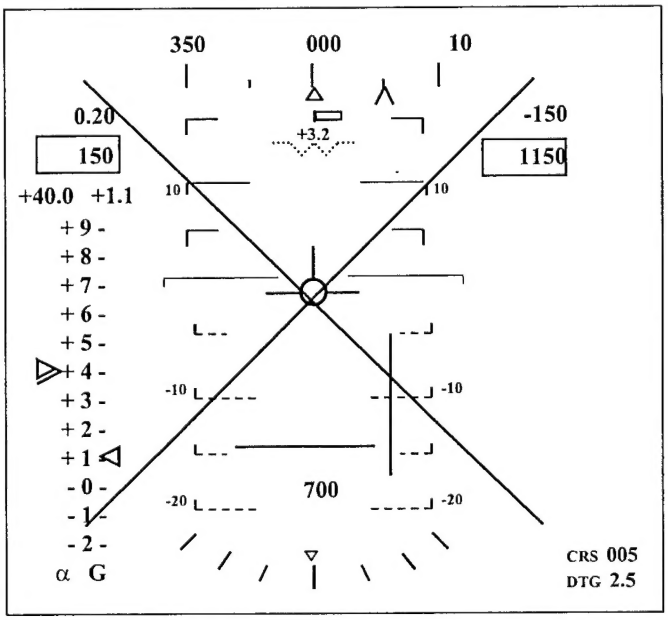
- Annunciator boxes
- Selected heading
- Commanded AOA pointer
- Commanded altitude pointer
- Needles
- Height above touchdown (HAT)
- Selected course
- Distance to go (DTG)
- Acceleration caret
- Derotation cue
- Wave-off X



Derotation Cue



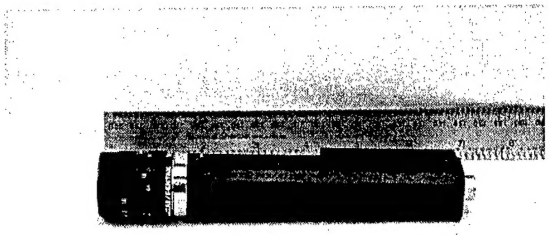
Go Around



Video

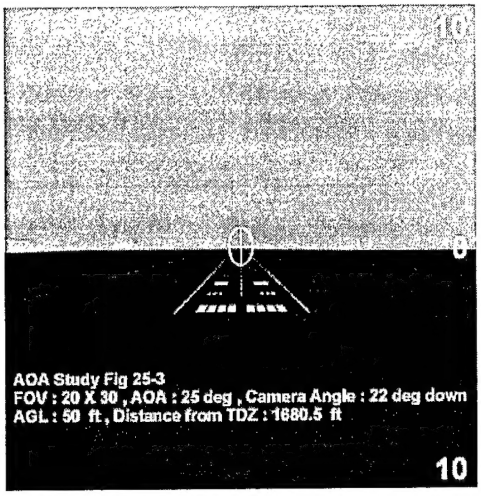
- **Provides indirect view of runway during approach**
  - Runway FOD
  - Gross alignment
    - No symbology overlay of touchdown point
- **Camera mounted internally in lower aspect of nose**
  - High alpha view of runway
  - No obstructions from nose gear
- **Display located on instrument panel behind stick**
  - Easy to scan with DDI and HUD
  - Daylight readability issues
  - Potential obstructions due to stick
- **Flight testing prior to ESTOL flights**

Camera

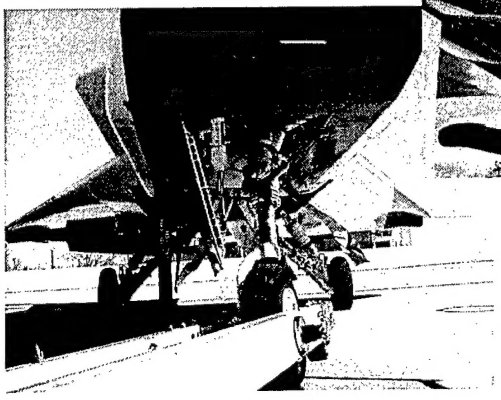


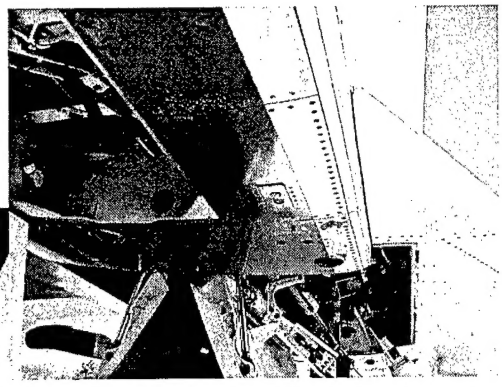
- **Ground tests to evaluate FOV of various lens**
- **Use of simulations to determine mounting angles**
- **Mounting location to provide clear view**
- **Flight tests to verify design concepts**

Simulated Video Image

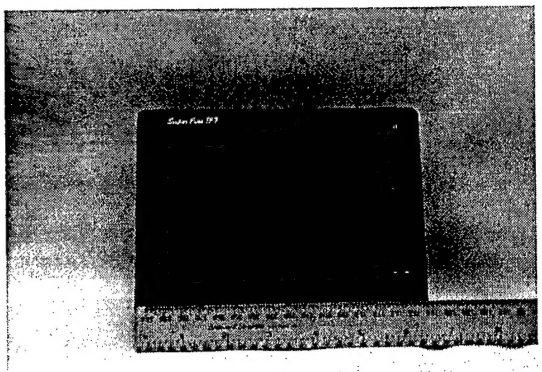


Camera Location



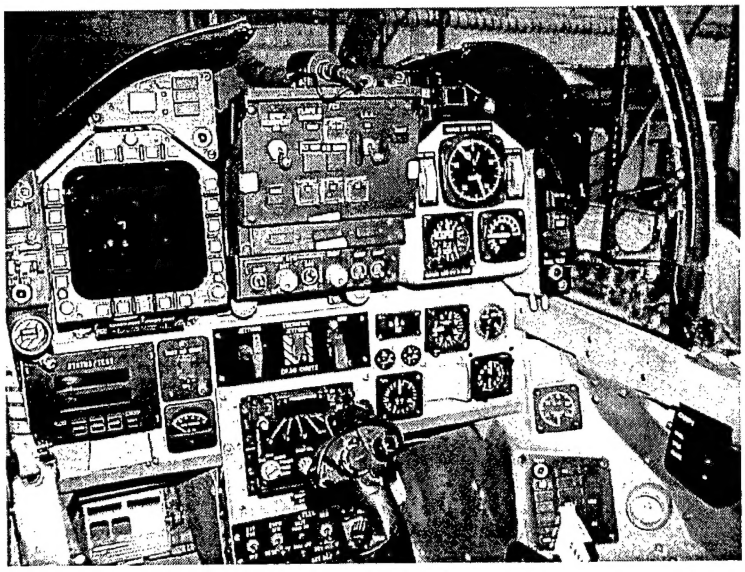


Display



- **Video on DDI not feasible**
- **Ground tests to compare off-the-shelf displays**
- **Flight tests to evaluate display location and video quality**
  - Camera positioning, daylight readability, etc.

Video Display Location



Summary

Application of human factors design concepts will enhance the safety and effectiveness of the VECTOR program.